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ABSTRACT

Curricular development in undergraduate programs in the biological, physical, and mathematical sciences at a number of colleges and universities are described. One common theme is the continuing interest in computers in higher education. As the student bodies of many campuses become more heterogeneous with increasing enrollments of minorities and adults, science departments are adapting their offerings to accommodate different learning styles. Interdisciplinary studies, cocperation between academic science and more applied fields, interinstitutional projects, and school-community programs are among the developments in undergraduate science education. The following programs are described: Queensborough Community College's Comprehensive Improvement of Astronomy Education Program; Hope College's Comprehensive Instructional Program for Multidisciplinary Problem-Solving; Xavier University of Louisiana's CAUSE Project; Ohio State University's Teaching Calculus with Programmable Calculators Program; College of Mount St. Joseph's Modular Anatomy and Physiology Course for Allied Health Students; University of Rochester's Integrated Chemical Information Curriculum Program; California State University at Fullerton's Development of Reasoning in Science Program; Walla Walla College's Interdisciplinary Teaching Cooperative in Marine Sciences Program; and Oklahoma State University's Undergraduate Applied Mathematics Component in Cooperation with Regional Industries Program. A listing of additional programs and resources is included. (SW)

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Innovations in Science Teaching

All too often, administrators and even faculty think only of the humanities when they discuss liberal education. Literature, history and philosophy are undeniably important components of a well-balanced education, but biology, chemistry and mathematics are equally important in preparing students to deal intelligently with today's world. This issue of the *Forum for Liberal Education* is dedicated to the idea that quality teaching in the sciences is critical to any liberal education program.

The specific focus of this issue is curricular development in undergraduate programs in the biological, physical, and mathematical sciences. (Subsequent issues will discuss innovations in the social sciences and programs of science literacy for non-science majors.) While the programs featured here are located in institutions ranging in size from large universities such as Ohio State to small colleges such as Walla Walla, and focus on subjects from precalculus to solar energy, certain common themes emerge. First is the continuing interest in computers in higher education. The development of microcomputers has extended access and use of computers to more disciplines and many more students. Further, the advent of programmable hand-held calculators allows students such as those at Ohio State to learn many computing concepts without direct access to the computer itself. In addition, many science programs go beyond the use of statistical manipulation to include computer graphics in advanced mathematics or in applied fields such as engineering. The computer can also be a research tool of a different sort, providing access to information as it does for chemistry students at the University of Rochester.

As the student bodies of many campuses become more heterogeneous with increasing enrollments of minorities and adults, science departments are adapting their offerings to accommodate different learning styles. Some programs adapt specific learning theories to classroom instruction; the works of Bruner and Piaget have inspired experiments in teaching such as the one at the California State University at Fullerton. Other institutions have been more eclectic, providing several methods by which students can learn necessary scientific concepts. The Alternative Pathways approach at Xavier University of Louisiana combines lectures, labs, audiovisual, tutorial, and other techniques for students, many of them poorly prepared for college level work. Of course, a number of science programs continue to experiment with computer-assisted instruction (CAI), modular formats, and personalized systems of instruction (PSI).

Cooperation is a theme that can be identified in several contexts. First is a continuing emphasis on interdisciplinary studies. In some cases, faculty members concentrate on scientific problems which are inherently interdisciplinary such as environmental issues at Hope and Walla Walla. In others, the cooperation comes between academic science and more applied fields; the College of Mount St. Joseph offers a new physiology course of special interest to allied health students. A third level of cooperation is interinstitutional projects, such as the astronomy facilities near Greensboro, North Carolina or the development of computer sets

by ten liberal arts colleges jointly with the University of Iowa. Finally, institutions are reaching out beyond the campus to the wider community. Field stations, community events, real problems from business are all increasingly evident in science curricula.

The last theme is preparation for careers in science and related areas. A number of institutions, including Oklahoma State and Walla Walla College, solicited problems from local industries to be incorporated into coursework. Other projects address the scientific component of preprofessional or professional training. At the same time, colleges are increasingly concerned with providing specific skills and knowledge in science that are transferable to the world of work.

The programs featured in this issue of the *Forum*, most of them supported by grants from the National Science Foundation, can only begin to illustrate these themes. For that reason, the issue includes a listing of additional programs and resources for those readers interested in pursuing in greater depth the challenges of curriculum innovations in the natural sciences.

Queensborough Community College

Comprehensive Improvement of Astronomy Education in an Urban Community College

Queensborough Community College, a public, urban, two-year institution with 12,000 enrolled undergraduates, has inaugurated a program to improve astronomy education by building an observatory, developing a laboratory manual, implementing a program of student-oriented research and astrophotography, providing alternate learning resources, and by initiating a comprehensive evaluation of astronomy education at Queensborough.

The program developed in response to the fact that QCC nonscience majors, particularly minority, female, and handicapped students, usually fear and dislike science and often take a science course only to satisfy their four-credit general education requirements. Astronomy is the most popular science course for these students. Fascination with such topics as the possibility of extraterrestrial life, astrology and the horoscope, quasars, black holes, science fiction and space movies lures about 350 students into astronomy classes each term. Once enrolled, their program stresses the interdisciplinary nature of astronomy, including physics, chemistry, geology, and biology. Queensborough's Homebound Program is designed to reach the totally handicapped and homebound; these students frequently take the course by conference telephone. In short, astronomy provides an extremely valuable bridge between science and the non-scientific community, and the project has already achieved enrollment increases.

Because of its height, air quality, and location in Bayside, Queensborough is the best suited unit among the 19 two-year and four-year colleges of the City University of New York for an observatory. The newly constructed observatory houses a $10,000, observatory-quality 12" Cassegrain telescope and seven other QCC-owned telescopes (four 6-inch reflectors, an 8-inch reflector, an 8-inch Cassegrain, and a 3-inch refractor). A senior-citizen student donated the large Cassegrain to the college in 1975. Permanently established on the library roof, the telescopes no longer have to be moved for each observing session. They now stand on permanent bases, have electrical outlets for their electric clock drives, and are protected from the wind, which eliminates the interference of vibrations.

QCC faculty developed a lab manual in the absence of a single all-purpose standard laboratory manual devoted to the instructional aspects of astronomy. The 20 observational and indoor exercises match course objectives, local sky conditions, available equipment, and student level and interest. The indoor exercises provide instruction when smog, light pollution, or cloud cover prevents observational work and help eliminate frequent protests against compulsory laboratory sessions. The exercises are being evaluated and modified on the basis of student reactions.

The program is providing auto-tutorial materials and instruction for remedial, enriching, and Homebound instruction. Students possess diverse abilities and interests, and they learn at different rates and in different ways. The personalized instruction is putting real flexibility into the astronomy program. This new approach will provide a self-paced program in astronomy for students who can profit from these alternative learning resources in addition to the three lectures per week and the regular two-hour laboratory session. Project staff is developing, testing, evaluating, modifying, and producing videotapes, audiocassettes and written self-instructional materials on the following topics for the remedial learning supplement to the course: Understanding the Sky Viewed from Earth, Light and Telescopes, the Stars, Stellar Evolution, Galaxies, Cosmology, Meteors, Life in the Universe, and many others. Topics for general enrichment include Special Relativity, Cosmology, Solar-Terrestrial Relationships, and Comparative Planetology. Auto-tutorial materials are located in the Science Library and are being sent to Homebound students who are able to complete many laboratory activities at home.

Another important objective is to generate a comprehensive program of self-assessment that can be applied to others areas of science education at Queensborough in post-grant years. A science attitude survey will measure changes in undergraduates' attitudes toward astronomy and science in general. Actual student use of the auto-tutorial materials and their participation in student oriented research projects and astrophotography will be carefully monitored by keeping records of the total number of student users.

Substantial contributions from 1827 students and parents, 25 PTA's of Queens high schools, banks, financial institutions, private foundations, businesses and individuals, attest to a tremendous local interest. In response, Queensborough is making the observatory available to other institutions, school groups, and amateur astronomy groups. Regular community viewing nights are being held for the public. Another long term benefit of the project is its replicability for other urban community colleges where astronomy enrollments are similarly increasing.

The personalized approach of the course, the dramatically visible presence of the observatory itself, and the thrill of seeing sky objects with a telescope will increase interest in astronomy and science in general. For many students, astronomy may constitute their only formal undergraduate science education. For this reason alone, it is crucially important to provide high quality science curricula. In a modern scientific culture, citizens in a democratic society must often judge science-related societal issues; a high quality science education for undergraduates will improve the level of their participation in the democratic process.

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Hope College

A Comprehensive Instructional Program for Multidisiciplinary Problem-Solving

A new program currently being developed and implemented at Hope College provides an opportunity for upper level undergraduates to examine real environmental issues from various scientific perspectives. Based on the assumption that complex problems confronting modern society require knowledge that crosses disciplinary boundaries, it allows students trained in specific areas to see how different disciplines interact in the problem-solving process.

Curriculum change, faculty development and equipment acquisition form the three major components of the National Science Foundation-funded project. While some of these changes will not be made until the 1980-81 academic year, a number of them have already been integrated in the science curriculum. Mathematics, physics, and engineering programs have been expanded to include an intermediate statistics course for scientists, applied numerical methods, a science-oriented computer course, materials science, and an introduction to solid mechanics. These courses are designed to give students the practical problem-solving experience necessary for future study and employment.

Central to the students' increased competence in solving problems is the idea that they apply knowledge and methods learned in class to real situations. The professors therefore have chosen two environmental problems for intensive, year-long studies by the students. The first, dealing with land resource utilization, was begun in the fall of 1979. Attempting to determine the best long-term use of land in a township extending from Lake Michigan to the town of Holland, students majoring in geology, biology, sociology, economics, and politial science analyzed the characteristics of the land, its capacity to support various human activities, and the effects of those activities on the area. In the spring, 1980, the students will work independently using data acquired during the previous semester to write a comprehensive land use policy statement.

During the fall, 1980, students will begin to study the second problem, involving the identification of the source, composition, and distribution of atmospheric particulates over Holland, Michigan. Because this task requires that a number of separate questions be addressed, the problem-solving activities will be different than those concerning land use policies. Students in various courses will work simultaneously to solve problems applicable to specific disciplines. Those taking analytical and environmental chemistry will study the nature of the particulates while students in marine geology and sedimentology will relate the composition of these materials to geological conditions prevalent in the source region. Microbiology, physiology, and biology students will investigate the chemical and toxicological properties of the particulates. Finally, computer science students will chart distribution patterns of the airborne matter within the region. In the spring semester all of the students will register in an Interdisciplinary Studies course and will work on a problem whose solution requires materials gathered from all of the previous semester's activities.

To aid the students in these courses the college has acquired additional equipment. New geophysical and soil evaluation instruments have been helpful in the land use study. Hope now has an X-ray detector to be used with a scanning electronic microscope or with a low-energy accelerator in X-ray flourescence analysis of samples. Plans are also being made to purchase additional computer materials to accomodate increased statistical analysis activity in that area.

Although the college has not yet instituted the faculty development component of the program, professors are initiating plans to conduct summer workshops in such areas as microelectronics technology, biometrics and geometrics, and materials science. These sessions will be designed to increase the competence of the instructors so that they will be able to contribute more fully to the academic and professional development of the students. In all, the program remains faithful to Hope College's commitment to provide quality science education and to prepare students to assume responsible roles after graduation.

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Xavier University of Louisiana
CAUSE Project

One of the major problems facing science faculty is to increase access to science-related careers for educationally disadvantaged students without sacrificing quality education. This problem is especially acute in entry level courses. At Xavier University, the CAUSE project has supported modification of teaching techniques in these courses so that both well prepared and educationally disadvantaged students have reasonable chances for success.

At Xavier, over one-third of all students are in health or natural science fields, with 50 percent of the freshmen class indicating an intent to major in one of these areas. However, many students do not have the strong preparation necessary for success in the sciences. The goals of the project, then, are to improve performance in and reduce attrition from the entry level science major courses in biology, chemistry, mathematics, and physics.

The project has several strategies for achieving these goals. First, each department has specified objectives for the entry level course it offers. In this way, all sections of a given course will cover the same content at the same rate throughout the year. This approach also enables departments to provide assistance to inexperienced faculty members. At the same time, each department has developed a handbook for students which contains content objectives, sample problems, and references to alternative materials.

Secondly, the four departments administer common final examinations in all sections of a given course in a given semester. While chemistry uses a standardized test from the American Chemical Society, the other three departments have developed specifications for local exams of a comparable nature. By these means, the program's objectives can be measured and student performance compared across years.

The third strategy is the development of "alternate pathways to learning"—audio-visual materials, cassettes prepared by instructors, computer-based instruction, intensive tutoring, and other learning aids to help students with difficulties. Students are not limited to the traditional lecture and text method for learning course content, an important factor especially for those students who lack strong preparation. The four departments together have planned, renovated, and furnished an Alternative Pathway Learning Center in a section of the library where materials are centrally located. As an indication of its success, over 15,000 visits (from a 1700 student population) were made to the center in one month.

The alternative pathways concept has been extended to laboratory sections as well. All four departments have developed at least five Piagetian-based experiments designed to promote analytical thinking skills; chemistry has created an entire two semester sequence of such materials. Poorly prepared students especially benefit from the learning-by-doing approach to understanding scientific concepts.

The CAUSE project has been successful in achieving its stated objectives. In the introductory biology course, for example, a randomly selected sample of students took the CLEP General Biology Examination without special preparation. In comparison with a similar group of students in the previous year, the CAUSE students scored 27 percentile points higher, with the average score in 1978-79 higher than the highest score in 1977-78. While other departments have not experienced such dramatic gains, test scores have shown increases since the project began.

More students are also completing entry level science courses satisfactorily. Completion rates have increased as much as 30 percent in some courses under the project. Also, student evaluations of the courses have been more favorable since the introduction of these new strategies. In chemistry, for example, students have rated the course highly, at the same time indicating that they have worked harder in it than in other classes.

The CAUSE project has been a direct extension of Xavier's overall philosophy of "standards with sympathy"—coupling high academic expectations with mechanisms which allow disadvantaged students to attain success. The results of this project demonstrate the possibilities of increasing retention rates and also improving achievement in entry level science courses.

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Ohio State University
Teaching Calculus with Programmable Calculators

Faculty members teaching calculus find that many students master the techniques of calculus without understanding the sophisticated theories that underlie them. While other institutions have had success with computer-assisted instruction in mathematics, financial and logistical problems prevent wide adoption of these methods at Ohio State. Instead, calculus is taught with hand-held programmable calculators, which are in reality small computers.

The project is designed to enable students to acquire a blend of technique, theory, and application that will lead to a better intuitive grasp of limit processes, an understanding of mathematical analysis of data, and practical methods for approximating solutions to complicated problems. Programmable calculators have sufficient computing power to make limits vividly apparent, to make approximation techniques practical, and to fit curves to experimental data. Thus average students are able to go beyond routine applications of formulas to a real understanding of the mathematical theories they will need in subsequent science and engineering courses.

Faculty members have developed textual materials, illustrations, and problem sets for integrating the calculators in a traditional format. Students meet three times a week for lecture and twice a week with a graduate assistant for recitation and supervised problem solving; they also have

access to a computing laboratory with more powerful calculators.

The results of the project have been successful. On questionnaires and in interviews, students, primarily engineering majors, indicated that they understand the most important concepts of calculus. In addition, many of them found the manipulation of ideas and numbers to be interesting and enjoyable. Perhaps most important, students have enough understanding to approximate solutions and are willing to try, even if they are wrong.

In large part, then, the Ohio State mathematics department has achieved its goal: average students are able to learn mathematics experimentally, to discover processes and relationships now considered theoretical, and to apply these new insights to the solution of scientific and engineering problems.

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College of Mount St. Joseph
Modular Anatomy and Physiology Course for Allied Health Students

In recent years students enrolled in Elementary Anatomy and Physiology at the College of Mount St. Joseph have represented such fields as physical education, home economics and dietetics, music therapy, respiratory therapy and medical laboratory technician programs, as well as liberal arts and business. Because of the resulting diversity in student backgrounds, interests, and motivations, the biology department has restructured the two semester course, combining personalized system of instruction, audio-tutorial, and self-paced study approaches with the traditional lecture/laboratory format. The new course, a series of learning modules, includes one semester of highly conceptual study of physiology and anatomy for all students, followed by a semester of shorter courses in which students from particular disciplines focus their attention upon various topics in physiology that apply to their fields.

The first semester program is divided into five units, each consisting of one or more one-week modules. Before the beginning of a module, students receive study guides, designed to complement the textbook by stating lesson objectives and by suggesting procedures, outside reference materials, and audio-visual aids located in a learning center. Worksheets included in the study guides help students apply the information to specific problems and provide continuity between modules by integrating each week's lessons with those of preceding and following weeks. Lectures do not cover all of the material; rather they focus on specific topics, often ones which traditionally present problems to the students. In some cases one of the week's three lectures is replaced by presentations by guest speakers or by individual or small group consultations with the instructor. On the last day of the module, students take quizzes which they then correct themselves, thereby gaining immediate feedback.

In labs, students view films or perform such activities as dissections or cardiac tracings. They often use the time in these small group sessions to ask questions and to review course material for multi-unit exams.

During the second semester students choose from among a number of short courses relating to their specific disciplines. Those in home economics, dietetics, medical laboratory technician or respiratory therapy programs elect Metabolism; students studying physical education, physical therapy, or music therapy take The Body in Exercise; Respiration and Homeostasis is designed for students enrolled in the respiratory therapy program. All students may take the very short Reproduction and Development. The format of these courses is similar to that of the first semester course.

An important component of the program is the learning center. Open from 8 a.m. until 10 p.m., it contains a variety of materials for optional student use. These materials, including slide-tape and filmstrip-tape presentations, 8mm filmloops, textbook tapes, models, and charts, help the students understand basic concepts. The great flexibility of learning provided by the center enables students to establish individual learning and study styles to suit specific needs.

Response to the program has been very positive. The second semester courses permit a more intensive study of body functions appropriate to professional concerns of students; the more relevant material and self-pacing nature of the courses increase student interest and motivation and improve attitudes and study habits, particularly among lower ability students. Instructors have found that by selecting fewer topics for study they have been able to use lecture time more effectively, thus enabling them to examine some subjects in greater depth than would be possible in a traditional physiology course.

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University of Rochester
Integrated Chemical Information Curriculum

Chemistry majors at the University of Rochester pursue a rigorous sequence of theory and laboratory courses to prepare for graduate work or professional careers. While these students have been taught traditional scientific fundamentals, they have been handicapped by being cut off from easy access to the large body of relevant knowledge hidden away in literature or in non-bibliographic data

bases. Thus this project incorporates instruction in chemical information retrieval into laboratory sequences for chemistry majors and graduate students.

The project introduces information research techniques at points in the chemistry curriculum when they are most needed—the spring semester of an organic chemistry laboratory and the beginning of the senior year, in which students do independent research under faculty guidance. Students are taught such skills as locating chemical and physical properties of substances, finding references to desired types of chemical transformations, identifying the registry number of compounds using *Chemical Abstracts* files, and conducting comprehensive subject searches. At the senior level, students learn to use computerized indices and data bases as well as printed references. In addition to helping students recognize the relationship between acquiring information and succeeding in lab, integration of these skills into regular laboratory courses promotes the idea that information retrieval is a normal and expected phase of research.

The project involves preparation of teaching materials for use in the organic chemistry lab, sets of practical questions as assignments, and guides to the literature organized according to the needs of the researcher rather than the structure of the literature. Seniors get special instruction in computerized search techniques of mass spectra and C-nmr files, the X-ray crystallographic data search system, *Chemical Abstracts*, and the *Journal of Synthetic Methods* files. Two seniors will receive special training each year, beginning in the summer of 1980, to aid other students in computer searching.

Both faculty and students have responded favorably to the program. For example, a faculty member new to the laboratory sequence made available as much time as necessary for chemical information instruction. Students have reported that they learned a great deal from searching both printed and computerized resources. Objective testing confirmed these impressions; juniors completing the third integrated laboratory scored higher on a test of information research skills than incoming graduate students.

This project in chemistry is designed to serve as a model for similar instruction in other sciences and engineering at the university, as well as the basis for a special topics course for Rochester area scientists and engineers. In addition, the materials developed will be available for use in chemistry programs in other colleges and universities across the country.

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California State University, Fullerton

Development of Reasoning in Science

Many entering college students function at the level of concrete experiences, unable to use all strategies of abstract thinking confidently and reliably. Yet most introductory science courses present concepts and principles at a formal level on the assumption that students can handle such material. The frequent results are course failures, student dropouts, and dislike of science. To alleviate these problems, faculty at the California State University at Fullerton instituted a new course, Development of Reasoning in Science: A Course in Abstract Thinking, as a supplement to, not a replacement for, introductory science offerings.

In the spring semester of 1977, faculty members from a number of physical science disciplines met together in a seminar to explore the implications of Piaget's research for science teaching and the intellectual development of science majors in college. Led by a psychologist familiar with the field, faculty members examined course content in their respective disciplines to identify items for inclusion in a new course organized around specific thinking skills rather than scientific content. While acquisition of scientific knowledge is an important goal, the main focus of the course is the intellectual development of reasoning patterns in students.

The course begins in a concrete manner. Students use logic and common sense in laboratory experiments with real objects. As they develop the intellectual abilities associated with concrete thinking processes, they move to more sophisticated problems involving abstract reasoning. By the end of the course, students should be able to function comfortably at the level of formal thought. For example, a physics problem asks students to manipulate a cart and inclined plane to discover some of the critical aspects of proportional reasoning. Students learn to identify variables, establish correspondence between variables, set up ratio relationship variables, and finally develop a relationship between two ratios using direct proportionality. At a higher level, students confront a situation which includes irrelevant variables and inverse proportionality.

When the course was first offered in the fall of 1978, the problems were organized by the disciplines of the faculty members teaching them. Subsequently, the course was reorganized around five thinking skills: correlation, combinational logic, isolation and control of variables, hypothetical-deductive reasoning, and proportional reasoning. The nearly forty lessons used in the course are those that best develop these skills, regardless of the discipline from which they are drawn.

In addition to evaluation of the course through tests and interviews with the 30 students involved, the project has conducted a series of research activities related to the teaching of abstract thought. With the cooperation of scientists and psychologists from nearby universities, the project has developed tests of intellectual skills using microcomputers, studied the combinational and proportional reasoning abilities of thousands of elementary and secondary students in eight California schools, measured

the thinking processes of hundreds of college students, and supervised several master's theses in psychology. All these tasks provide evidence for further development of the course in abstract thinking. In addition, staff members have presented papers and over 200 workshops on the reasoning patterns of students to approximately 5000 faculty members.

While the number of students passing through the course so far has been small, the implications are far-reaching. Both science and non-science majors should perform more successfully in their subsequent academic programs. The ultimate goal for the project is the development of a citizenry of lifelong learners who can cope with a rapidly changing and increasingly complex society.

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Walla Walla College

Interdisciplinary Teaching Cooperative in Marine Sciences

Walla Walla College, a small four year institution in southeastern Washington, stresses a thorough liberal education along with competence and specialization in a particular field. While the college has traditionally enjoyed a sound science program, faculty believe that their curriculum is enhanced by allowing students to gain practical experience through problems requiring knowledge from multiple disciplines. This effort to improve the training of science students led to the development of an interdisciplinary teaching cooperative among the biology, chemistry, engineering, and physics departments.

The cooperative, begun in 1977, was an extension of an existing program involving the biology and physics departments, in which biology and biophysics majors spent one summer doing course work and research at the Walla Walla College Marine Station, located on 45 acres of land near Puget Sound. An atmosphere of total immersion in science coupled with excellent student-faculty cooperation seemed an appropriate field work setting for students in engineering and chemistry, whose programs lacked opportunities for real world experience.

Participating professors developed the project in three areas. The first involved upgrading a laboratory facility located at the station by installing furniture and building storage areas. New gas, air, vacuum, and seawater systems were also included in the renovation.

The second objective was the integration of engineering and chemistry into the program by incorporating new courses of an interdisciplinary nature, and by initiating research problems designed to train students in the use and application of instruments outside their specific fields. A marine engineering clinic was started; teams of three or four engineering students worked under faculty supervision on projects that had been solicited from both outside and within the college. An engineering instructor was added to the staff of Biology Research Methods, and pairs of students worked on such biology/engineering problems as sound propagation by marine organisms and various structural stresses affecting form and design of those organisms.

The third component of the program consisted of a series of visits throughout the summer by marine scientists. Representing marine biology, biophysics, chemistry, and engineering, they conducted colloquia, workshops, and laboratory and field demonstrations contributing new ideas and expertise to the program.

Both students and professors responded favorably to the project. The geographic location of the marine station was conducive to student field experimentation as well as to efforts to establish an interdisciplinary teaching cooperative. Students also felt that the experience they gained in using sophisticated research techniques increased their capabilities, thereby helping to prepare them for future science work.

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Oklahoma State University

Undergraduate Applied Mathematics Component in Cooperation with Regional Industries

Faculty and administrators at Oklahoma State University, Central State University, and Phillips University, responding to a state-wide need to incorporate applied mathematics instruction into undergraduate curricula, have developed a program which emphasizes basic problem solving skills while permitting communication between students and non-academic professionals engaged in mathematics work. With the cooperation of regional businesses they have established a network of industrial personnel willing to contribute their expertise to the program, and have designed an applied math course which can be adopted by other schools in the state.

Work on the project began during the summer of 1978. Three teams of two professors from each of the consortium schools travelled throughout the region to identify industrial resource persons in the government and private sectors who would act as consultants to the program. From these persons the instructors obtained descriptions of actual problems suitable for an undergraduate applied math course. The personnel and problems represented a variety of local industries including oil companies, a medical center, a machine shop, Southwestern Bell Telephone, and Boeing Aircraft Corporation. The staff held bi-weekly meetings during this initial period to classify the problems according to their nature of difficulty and level of background and experience needed to work with them.

The professors devoted the 1978-79 academic year to developing the case study course. During the fall semester the course was offered on a pilot basis to students in the three consortium universities. Although there were some juniors and graduate students in the program, most were seniors majoring in math. The course was divided into three segments, each corresponding to a problem chosen from the problem bank. After a brief introduction by the instructors providing background to the task, the industrial resource person came to one of the campuses to present the problem to the students. The presentation was broadcast simultaneously via a state-wide television network to classes in the other schools. At this time students examined the problem to determine what materials were needed to solve it; resource faculty on hand gave assistance by suggesting useful texts. Each student was then required to decide upon and analyze a mathematical model in an attempt to solve the problem. This independent work was supplemented in class by group discussions among the students and professors. After each student submitted a professional-style technical report outlining the problem and its solution to both the professors and the resource person, all students and faculty gathered with the professional representative at one campus for an informal discussion about the problem.

In January, 1979, the professors met to evaluate the initial experience and to plan for the spring semester course in which six other institutions in the state would participate. Although reaction to the course was generally favorable, they had to make a few revisions. Difficulties in scheduling resulting in broadcasts at odd hours required that the television shows be changed to video-tape presentations to be used at each institution. Because many students lacked sufficient preparation to understand the presentations fully, the instructors adjusted their short introductory sessions to incorporate vocabulary and more background information. With these changes instituted, the course was taught again in the spring of 1979.

During that same semester Oklahoma State University hosted an applied mathematics symposium to provide an interchange of ideas related to the field. Over 100 academic and non-academic participants listened to presentations made by mathematicians employed in industry and by nationally recognized applied mathematicians. The participants also engaged in open discussions centered on the role of applied mathematics in the undergraduate curriculum.

After one year, response to the program continues to be positive. The students feel that they have benefitted from the program in various ways. In addition to seeing how mathematics is used in real situations, they have also developed their oral, written, and research skills. Both Oklahoma State and Central State are offering the course in the spring of 1980; Phillips, a much smaller school, will wait one year before offering it again. Efforts have been made to add materials to the bank, which now has 57 problems available for use by Oklahoma area schools. Instructors on many campuses are supplementing existing courses with these resources and using them as the basis for independent study programs. An applied mathematics workshop planned for May, 1980 will focus on identifying other means of incorporating the materials into mathematics curricula. Participants from regional community colleges, colleges, and universities will also have an opportunity to become familiar with the kinds of mathematical problems occurring in local business and industry by working through some of the problems in the bank. This state-wide cooperative effort will thus help provide an exchange of knowledge and ideas between the colleges and the community.

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Additional Programs

The following institutions have programs which have recently come to the attention of the *Forum*.

Colorado State University, Fort Collins, CO 80523
Cooperative Education in Mathematics—The math department at Colorado State University is designing a cooperative education program to prepare upper level undergraduates for non-academic careers in mathematics. The three phase project aims to promote gradual development of applied mathematics skills. In the first stage students work in class on pre-analyzed, real life applied math projects, while the second stage involves teams of students working under faculty supervision on projects solicited from regional industries. The students then gain practical experience through on-site internships in area businesses.
Wilson E. Brumley, Department of Mathematics

Georgia Institute of Technology, Atlanta, GA 30332
Effective Utilization of Instrumentation in Undergraduate Chemistry—In response to the needs of undergraduate programs for better instrumentation, Georgia Tech is serving as a regional resource for chemistry education. The program involves short courses for faculty on more effective uses of instrumentation in undergraduate courses, a summer program for chemistry students, access to instrumental services on an individual basis, and a mobile van providing maintenance and repairs for chemistry equipment. The goals include more uniform courses to improve transferability of students and strengthened chemistry education, especially at smaller colleges, by providing more experience with modern techniques.
J.A. Bertrand, Director, School of Chemistry

Lawrence University of Wisconsin, Appleton, WI 54911
Video-Taped Problem Solutions—Students taking introductory physics courses frequently experience difficulty in initiating individual problem solving efforts although they understand the concepts involved. The physics department makes video-tapes available featuring pre-recorded problem solving demonstrations being performed by experienced instructors. The 160 presentations, located in a media center, provide students greater opportunity to see these processes than would normally be possible in class.
David M. Cook, Associate Professor of Physics

Pennsylvania Institute of Technology, Upper Darby, PA 19082
Energy Awareness in Engineering Physics—Pennsylvania Institute of Technology, a two-year associate degree granting institution, has developed an Engineering Technology Program designed to prepare economically and academically disadvantaged students for careers requiring specific energy technology skills. After surveying local industries to identify desired skills, instructors have upgraded existing engineering physics courses by incorporating energy-related materials and have created new courses emphasizing basic energy education.
Richard B. Thomas, Project Director

St. Petersburg Junior College, St. Petersburg, FL 33733

Student Field Experiences in Natural Sciences—In response to increased student interest in the natural environment, this project is designed to develop field exercises by extending the length of trips and by increasing the number of field locations. It will also provide investigators with the time to make reconnaissances of field sites, to organize and prepare field manuals, road logs, maps, quizzes, and especially programmed slide/tape materials as a preview to field experience. Funds from the National Science Foundation are being used to finance a van for the trips. Enrollment in the sciences has increased as a result of the program, and, in addition to existing programs in botany, geology, and oceanography, there is now field experience in the Introduction to Biology course.

Marvin L. Ivey, Project Director

Southern Illinois University at Edwardsville, Edwardsville, IL 62026

Modular Instruction in a Chemistry Course for Underprepared Learners—An existing remedial chemistry course for underprepared learners has been restructured with a modular format. Materials produced for the 13 sequential modules include testing instruments for placement, prescription, and sequential evaluation, a comprehensive student manual, slide/tape programs for each module, and computer assisted instruction programs. Studies of the rate of student progress over three separate offerings of the course show that student progress is most consistent when combined with two regular class meetings per week, rather than with less structured formats where students tend to procrastinate at first and then make up time toward the quarter's end.

Dennis D. Staley, Academic Resource Center

State University of New York, Binghamton, NY 13901

Solar and Solar-Related Energy Course—As energy continues to be a major issue of national concern, both scientists and the general public are turning their attention to finding safe, low cost energy sources. The department of physics at SUNY-Binghamton, is designing a course focusing upon solar and solar-related energy. Available literature on solar energy, diagrams of solar energy devices, demonstrations using various solar devices, films, and other audio-visual presentations will be used to compare solar energy with other energy sources and to outline solar energy technology. Solar-related energy sources as wind, water power, and biomass conversion will also be examined. The department plans to offer the course at a late afternoon hour so that university students, teachers from area public schools, and adults from the community will be able to attend.

Carl R. Stannard, Department of Physics

Tri-College Center of Virginia, Lynchburg, VA 24504

Cooperative Curriculum in Chemistry—Members of the chemistry departments at Lynchburg College, Sweetbriar College, and Randolph Macon Women's College have restructured their programs into one coordinated curriculum, combining resources to develop additional courses, expand existing courses, and design joint seminars and research projects. Through this cooperative effort the schools are able to make maximum use of faculty expertise and expensive equipment, thus providing excellent chemistry education without increasing costs.

Carey Brewer, President, Tri-College Center of Virginia

University of California, Santa Cruz, CA 95064

Combining Computer Graphics and Video Modules to Improve Learning of Precalculus—Increasing numbers of students, especially minority, women, and returning students, require precalculus as preparation for calculus and other science courses. This project includes filming of 21 video modules including computer graphic sequences on key mathematical concepts. These instructional materials are designed to support student learning, increase success rates, achieve confidence and satisfaction in learning, and prepare students for more advanced courses.

Edward M. Landesman, Professor of Mathematics

University of North Carolina, Greensboro, NC 27412

Three College Observatory--In an effort to improve astronomy instruction, the Three College Observatory of Greensboro, a consortium consisting of the University of North Carolina at Greensboro, North Carolina Agricultural and Technical State University, and Guilford College, is sharing a new optical observatory located 25 miles southeast of Greensboro. Equipped with a 24-inch telescope, a low light level television camera, and an SEC vidicon camera, the observatory provides an opportunity for undergraduate students to gain knowledge of scientific procedures and equipment. A video-tape library supplements class lectures with television observations of astronomical phenomena under discussion.

Stephen Danford, Department of Physics, University of North Carolina-Greensboro

Rabinder N. Madan, Department of Physics, North Carolina A&T State University

University of Oklahoma, Norman, OK 73019

Strategy for Improving Mathematics Instruction in Large Classes—Mathematics faculty at the University of Oklahoma have developed a new, nine-hour sequence for students in biological sciences, social sciences, and business administration. With dual objectives to improve the quality of instruction and increase the relevance of the courses, it emphasizes the ways in which math processes are used in real situations. The instructors have also designed a mathematics laboratory for students to work individually with "talking pages"—supplemental diagrams and texts accompanied by four-minute records, each featuring a specific topic in applied mathematics.

Harold V. Huneke, Department of Mathematics

Wellesley College, Wellesley, MA 02181

Geology Program for Computer Literacy—In an effort to combine computer techniques with existing curriculum, faculty in the geology department are developing computer modules for use in three courses: Introduction to Geology, Historical Geology, and Geometrics. Representing increasing levels of difficulty, the modules begin with exercises designed to introduce the computer as a graphic device used in simple problem solving and then become more advanced as the students gain proficiency in writing computer programs and applying sophisticated techniques to advanced geological studies. The overall results will be to reinforce a campus-wide commitment to achieve computer literacy as well as to improve geology instruction.

Harold E. Andrews, Office of the Science Center

Western Michigan University, Kalamazoo, MI 49008

Preparatory Course for Science Majors—Freshman students taking this introductory methodology course must complete various assignments relating to a particular subject of science inquiry: formulating questions to be answered, compiling a pertinent bibliography, writing performance objectives, and defining basic terminology from several disciplinary perspectives. These exercises not only help increase skills necessary to develop well-articulated study projects from a wide range of resources but also provide students with an integrated conceptual frame of reference with which to approach issues within their field of study.

Lawrence Israel, Office of the Dean, College of General Studies

Resources

Burke, James. *Connections*. Boston: Little Brown and Company, 1978.

This book is the companion text to a ten part series of television programs produced by the British Broadcasting Company. In it the author attempts to examine eight recent inventions that have dramatically changed our lives—the atomic bomb, the telephone, the computer, the production line, aircrafts, plastics, guided rockets, and television—demonstrating how they are the results of a long process of events and human activities beginning in ancient times and continuing to the present.

Conference on the Roles of Science and Technology in General and Continuing Education December 16-18, 1979. Proceedings. Washington, D.C. Association of American Colleges. (To be published in March, 1980).

The conference addressed various issues in science and technology education, focusing on campus-wide instruction as well as on programs in museums, galleries, and public centers designed to provide information on current scientific and technological developments.

A Guide to Undergraduate Science Course and Laboratory Improvements. National Science Foundation, Washington, D.C. SE 79-40.

This book has two purposes. It is a report of activities carried out at colleges and universities during 1976-1980 with support from the National Science Foundation's Local Course Improvement (LOCI) and Instructional Scientific Equipment (ISEP) Programs. More importantly, it is intended as a reference for persons interested in current and laboratory developments in the sciences at the undergraduate level.

Haight, G.P. "Balancing Chemistry's Priorities." *Change: The Magazine of Higher Learning*. Vol. 8, No. 2 (March 1976), pp. 4-5.

Included in a six-part series entitled "Report on Teaching," this short introductory essay briefly summarizes four problems currently facing chemistry professors—what materials are appropriate for an introductory course, how to deal with a diverse student body, how to incorporate modern technical aids into the chemistry curriculum, and ways to train students to think analytically. Other articles in this issue deal with such topics in chemistry education as the use of computers in teaching, chemistry curricula in non-traditional settings, and teaching environmental chemistry. Subsequent *Change* issues which include similar reports on teaching sciences are:

Biology, "Report on Teaching, 2." Vol. 8, No. 6 (July 1976)
Mathematics, "Report on Teaching, 3." Vol. 9, No. 1 (January 1977)
Physics, "Report on Teaching, 5." Vol. 10, No. 1 (January 1978)
Interdisciplinary Studies, "Report on Teaching, 6." Vol. 10, No. 7 (August 1978)

Hungerford, Harold R., et al. "Goals for Curriculum Development in Environmental Education." 13 pp. 1978.

Available from the Educational Resources Information Center (ERIC); the *Resources in Education* number is ED 156 536. The goals listed in this paper were proposed at the Tbilisi Intergovernmental Conference on Environmental Education in 1977. The goals are grouped at four levels: ecological foundations, conceptual awareness, investigation and evaluation, and environmental action skills.

Journal of College Science Teaching. Washington, D.C.: National Science Teachers Association.

Published five times a year, this journal focuses on current developments in postsecondary science education. It also features short descriptions of innovative teaching methods used at colleges and universities throughout the country.

Listings of FY 1979 Awards, Comprehensive Assistance to Undergraduate Science Education (CAUSE) and Local Course Improvement (LOCI). Available from Division of Science Education Resources Improvement, Washington, D.C. 20550.

These lists are prepared annually and contain information about the current year's awards. They are available to the public at no cost to the individual requester.

Mohrman, Kathryn, ed. "Integrating Sciences and Humanities." *Forum for Liberal Education*. May 1979.

This issue of *Forum* focuses on innovative interdisciplinary programs that combine themes from science, humanities, and social science.

Paldy, Lester G., "Analysis of NSF CAUSE Awards for FY 1979," *Journal of College Science Teaching*. November 1979, pp 98-101.

This is the third in a series of articles since January 1977 which have treated the historical development of the Comprehensive Assistance to Undergraduate Science Education program of the National Science Foundation. This particular article is primarily a statistical summary of the FY 1979 program.

Sanzone, George. "Undergraduate Research in Chemistry: A Liberal Arts Subject." *Journal of Chemical Education*. Vol. 54, No. 9, 1977, pp. 556-558. (EJ 179 826)

This brief article describes a liberal arts program designed to teach chemistry to non-chemistry majors.

Science Education News. Washington, D.C.: American Association for the Advancement of Science.

This newsletter provides information about current programs and projects dealing with science education and research. It also includes brief summaries of new publications in science education.

Stone, DeWitt B. and Judith B. Erickson, "CAUSE, ISEP, and LOCI—A Three-Program Approach to College-Level Science Improvement, Part I," *Science Education*. In press.

An historical description of the three programs, Comprehensive Assistance to Undergraduate Science Education (CAUSE), Instructional Scientific Equipment Program (ISEP), and Local Course Improvement (LOCI) is presented. This article is the first of two parts. The second will deal with some current issues in undergraduate science education. The National Science Foundation will invite reader reaction to the possible Foundation stances in regard to the issues raised.

Technology in Science Education: The Next Ten Years. National Science Foundation, Washington, D.C., July 1979.

This report contains four commissioned papers which discuss the role which technology may play in science education over the next ten years. Much of the discussion centers on the use of computers both now and in the foreseeable future. A list of resource documents is appended to the report.

White, Alvin H. "Humanistic Mathematics: An Experiment." *Education*. Vol. 95, No. 2, pp. 128-133.

White's essay reports on an experimental calculus seminar which tested the effectiveness of an informal, student-centered approach to what is traditionally a very structured subject. Special attention was given in the course to developing students' confidence in their ability to approach the material independently. In addition to details about the format of the course, White includes reactions from the students who participated in it.

Whitehead, Alfred North. *The Aims of Education*. New York: Mentor Books, 1929.

This classic book on educational aims and techniques includes several chapters that examine the mathematics curriculum and outline an approach to teaching the most essential concepts of modern scientific knowledge. Of particular interest is chapter nine, "The Anatomy of Some Scientific Ideas."

The Forum for Liberal Education

Volume II, No. 4

Kathryn Mohrman, Editor
Wayne H. Hoffmann-Ogier, Research Associate
Carol Buchman, Research Assistant

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The Forum for Liberal Education is a topic-oriented publication featuring a subject of importance for liberal education in each issue. It does not endorse or evaluate institutional activity. Rather, it describes various ways in which institutions of higher learning address important common concerns. Upcoming issues of the *Forum* will look at cooperative arrangements, academic advising, The Fund for Post-Secondary Education's *Project IV*, and the creative arts in the liberal arts curriculum. Contributions of program information from *Forum* readers are encouraged.

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